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OBSERVATIONS ON THE ANATOMY AND PHYSIOLOGY OF THE CAPILLARY BLOOD-VESSELS.

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ABOUT five years ago (some time in the spring of the year 1832), my attention was attracted by a peculiar optical phenomenon. One dark, cloudy day, I was observing very attentively a spider engaged in constructing its net in the window. I had continued watching the insect so long, and so intently, that I at last lost sight of it, and remained gazing, as we express it, on vacancy; when suddenly I noticed some object, apparently, floating in the air. What that object was, I could not then decide, and had it not been for its peculiar and marked appearance, I should have considered it to be nothing more than an optical illusion, and should have given it no further attention; but struck with the singularity of the phenomenon, I determined, if possible, to discover where the object was, and of what it consisted. It appeared to be floating in the air near the glass of the window, in view of which, a very dark cloud then happened to be. I noticed, however, that in whatever direction I turned my eye, the object moved with it; but that it also had a movement apparently independent of that of the eye, moving up or down or from side to side, though in the main it obeyed the motion of the eye. Placing a book, which I had in my hand, apparently between the object and the eye, I found that I could still see it, and that the nearer the book was placed to the eye, the smaller the object appeared; but that, what it lost in size, it gained in distinctness. Having closed one eye in order to determine whether I could see it with both eyes or with one only, I found that I could see it only with the right eye. I then imagined that it might possibly be some small body adhering to the eye-lids, eye-lashes, or cornea of that eye, and therefore endeavored to dislodge it, by closing the eye-lids and rubbing them against the eye-ball. I found, however, on opening them, that the object was still visible. I then made use of a mirror, in order to discover by its aid if anything could be seen adhering to the eye. The object was not reflected by the mirror, but still it was visible, as while looking at the mirror I could see it apparently moving about on different parts of the reflected image of my face. I noticed that the object, which presented a bright luminous appearance, was perfectly transparent, as I could see, without the least obscurity, other minute objects through it, as the letters of a book.

I then felt convinced that it must be in the eye itself. In adopting this opinion, however, I was at a loss to account for its moving apparently independently of the eye, and I did not find any explanation of this difficulty till some time after.

I had heard of moats, or, as they are technically and vaguely termed, *muscæ volitantes*, being seen in the eye, but I had never heard or read of anything being seen similar to what I then saw. The object appeared to me then, and has ever since, like an extremely minute tube of glass, or rather of the finest and most transparent isinglass, pierced with lateral pores. It is seen standing out in bold relief, entirely disconnected with anything else. Finally, after long and repeated observations, I came to the conclusion that it could be nothing else than one of the much-sought-for seriferous capillaries, with the lateral pores, which many physiologists, as Mascagni, Prochaska, Richerand, &c. have long supposed to exist in all the true capillaries. I was for a long time unwilling to believe myself authorized to come to this conclusion. I knew that the capillaries had never been observed in this way before, or if they had, the fact had never been made public, or had again sunk into oblivion. I could not believe it possible, as I knew must be the case if my supposition were true, that I could be the first to see *clearly* what must have been before, or rather in the very eyes of, millions during thousands of years.

As I was not at first acquainted with any means by which these vessels (for such I now *know* them to be) could at all times be rendered visible, I was frequently obliged, in order to observe them, to wait a long time, until they should become so accidentally. I very soon discovered that they were to be seen equally well in both eyes. The same vessel, however, is never to be seen with both eyes; but by that alone in which it exists. It can never be determined in which eye any particular vessel is, except by closing one eye and observing if it disappears or remains visible; after becoming acquainted with any particular vessel we of course can recollect in which eye it is seen; should we happen to forget, however, we should be obliged to go through the same course of observation as at first. I have discovered that the movement that these vessels appear to possess, independently of the eye, is not real, but only apparent; the deception is caused by our instinctively, and frequently altogether unconsciously, moving the eye in order to bring the object at which we are looking, or wish to look, into the axis of vision. Now as comparatively very few of these vessels are exactly in the axis of vision, we instinctively and unconsciously endeavor to bring them there, which, as they necessarily move in connection with the globe of the eye, we never can succeed in doing. Therefore, as we are not aware of moving the eye, and as we see the motion of the vessels, we conclude, erroneously, that they move independently of the eye; they apppear to be constantly gliding from the sight; this adds much to the difficulty of observing these vessels, and is, I am persuaded, one of the main causes which have prevented them from being distinctly seen until now.

To one particular vessel, however, the above remarks do not strictly apply; it does move independently of the whole globe of the eye; hence, though not always in the axis of vision, it frequently can be

brought there, and I have on this account often been able to keep it steadily in view for an hour at a time. This is the first vessel I ever saw in this manner; it is quite large, and is distributed to some transparent moveable part of the eye, which I suppose to be floating quite loosely in the aqueous humor; it cannot be the iris, for that is not transparent. This vessel is capable of very free motion upon itself; it is sometimes folded upon itself, so as to occupy a very small space; it is the vessel I have most frequently seen, and as it is larger and more distinct than any of the others, it is the one I have most studied. I shall notice it more particularly while speaking of the physiology of the capillaries.

It is not a reflected image of the capillaries that is seen in the eye, it is a transparent view of them. They have a bright luminous appearance, and stand out in bold relief; they appear, as I have before stated, as if entirely disconnected with anything else; the parts with which they are connected being so perfectly transparent as to be invisible, they appear as if they had been separated from all adhering parts by corrosion or the most minute and delicate dissection.

The pores are seen placed at distinct intervals in the parietes of the vessels, in which they are distinguished by their form and superior brilliancy.

It is probably not from any want of transparency that these vessels are visible; I suppose them to be rendered so solely by the power which their parietes, in connection with the fluids they contain, and by which they are surrounded, possess of refracting the light. The power which refraction possesses of rendering minute and transparent objects visible, is well known. The air itself is sometimes rendered visible by refraction, as is proved by those currents of this fluid which are seen circulating over a heated stove in a cold day. It is a law of light that it is always refracted in passing from a denser to a rarer medium, and vice versâ. The air immediately over the heated stove is of course rarer than the surrounding atmosphere, and the degree of refraction is in proportion to the different temperatures and depending differences of rarity of the strata of air. It has been objected that it is not the air itself which is seen under these circumstances, but minute particles of dust suspended in it. I believe it is the air itself which is seen; should it, however, be determined otherwise by future experience, I shall not have altogether failed in my object, which is to show, by this example, the great power of refraction in rendering minute and transparent objects visible. It must be admitted that it here renders objects visible which are not so under ordinary circumstances.

The greater the refractive power of these vessels, or of any part of them, the better they are seen. I believe that on this account, when a vessel is empty it is not seen at all. The lateral pores are frequently seen, while the parietes of the vessels in which they are situated are invisible, except the little ring which forms the boundary of the pores. This is not a mistake. I have frequently, while observing these apparently isolated pores, seen the parietes of the vessels to which they belonged become visible by being, as I suppose, entered by the fluids which usually circulate in them. The eye is frequently seen full of these pores, without any distinct vessel being seen; but in this case they

are never seen so distinctly as when the parietes of the vessels are visible, or as when only a few of them are seen.

The seriferous capillaries have never been seen, until now, even by the aid of the most powerful microscopes. But it is not on account of their minuteness; the microscope renders visible objects far more minute than they are; it is on account of their transparency, of their want of color, or their exactly agreeing in color with the tissues to which they belong, of the want of color of the fluids circulating in them, of their intimate commixture and adhesion, and probable exact correspondence in texture with the parts in which they exist. They are seen, but cannot be distinguished.

I have never seen any vessel in the transparent parts of the eyes which was not porous, except one, and that is a very large one in the left eye.

No vessel with an open extremity is ever seen; sometimes, indeed, one of the lateral pores appears as if it constituted the open extremity of a vessel; but I have always been able to discover the parietes of a vessel beyond it, and to determine that it was in the side of the vessel, and not at its extremity, as the vessels have no detached end. Hence I conclude that there is a continuous and direct passage provided for the blood from the arteries into the veins. This has otherwise been demonstrated by microscopic observations, injections, &c. The parenchyma of the ancients does not exist; neither do the exhalent vessels imagined by some modern physiologists, as Haller, Bichat, &c. Exhalation and secretion are effected by the common capillaries.

The capillaries may be regarded as constituting a distinct system of vessels, arising on the one side insensibly and without determinate limits from the minute arteries, and ending in the same manner in the minute veins on the other. With regard to form and structure, they are distinguished from the arteries and veins by being pierced with lateral organic pores, and probably by unknown differences in the texture and arrangement of their parietes. It is altogether probable that the lining membrane of the arteries is continued through them into the veins. They partake of the function both of the arteries and veins; they bring the blood to, and convey it away from the different parts; they secrete, exhale, and absorb. Neither the arteries nor veins exhale nor absorb; they are mere sanguiducts. In the arteries and veins the current of the blood is confined to one particular direction; in the capillaries this is most probably not the case; it may run through them in one direction one minute, and the opposite the next, as may be seen by the microscope in the transparent parts of some animals. The general tendency of their current, however, is from the arteries towards the veins. The capillaries have no valves.

It may be contended, by some, that what I suppose to be lateral organic pores, are not pores, but the globules of the blood circulating in the vessel. Now the red globules of the blood do not penetrate these vessels; everything is here perfectly colorless and transparent; a single globule of blood appears colored under the microscope, and objects are here rendered visible by the refraction of the light and the great magni-

fying power of the humors of the eye, which no microscope has ever enabled us to detect. Consequently I believe that if the red globules of the blood penetrated these vessels, I should see them colored. If it should still be contended that the globules of the blood do penetrate these vessels, but only after having been deprived of their color, I could not prove that they do not; I believe many of these vessels to be amply large enough to admit the red globules of the blood; but I *know* that what I take to be pores are not the globules of the blood. These pores are placed at distinct and even irregular intervals, they are seen to be seated in the parietes and not in the cavity of the vessel; besides, in one very large vessel, they are not seen at all. The globules of the blood circulate in the most minute red capillaries, in close contact with one another, like beads on a string. This is proved by microscopic observations; their movement can be seen. Now these pores are fixed and immoveable; they remain in the same relative position from day to day, and from year to year. Their existence is as evident in the most minute vessels as in those which are larger. In the larger vessels it is seen that they are not always equally open, being sometimes more, sometimes less so. They are likewise seen in the very performance of their functions. As these pores are frequently seen, while the parietes of the vessels to which they belong remain invisible, they have no doubt been described as *muscæ volitantes*. I have known them supposed to be globules of air floating in the aqueous humor; nothing can be more erroneous than the latter opinion. I have no doubt that, together with the parietes of the capillaries, they constitute the *muscæ volitantes* of the dying, and frequently cause them to pick at the bed-clothes. The lateral pores are the result of organic laws, by which the structure of the capillaries is suited to their functions; they do not result from those laws of inorganic matter which determine its porosity; they are not, then, mere inorganic pores, they are regularly organized; and without their existence in the parietes of the capillaries, these vessels could not perform their functions.

As I did not at first perceive any vessels which gave off branches, I supposed that only the most minute capillaries penetrated the transparent parts of the eye, and that on that account they did not ramify; but after some time I discovered that this opinion was not well founded; the vessels even here differ perceptibly in size; I frequently see their ramifications forming a distinct and beautiful network, the different filaments of which appear to be all of equal diameter. They anastomose with extreme frequency with each other. They are very often seen as fine as the finest hairs, and even in these the lateral pores are distinctly visible.

The fluids which circulate in the seriferous capillaries, being *usually* perfectly colorless and transparent, they cannot be seen moving in them; they cannot even be distinguished from the parietes of the vessels.

If there be any absorbents in the transparent parts of the eye, and there no doubt are, they must be seen as well as the capillaries; but as they most probably exactly resemble the latter vessels in form, I do not know how they can be distinguished from one another. The only dif-

ference which exists between them is probably merely vital and functional, and not mechanical, or of such a nature as can be discovered by the eye. It has been suggested to me that the lymphatics pursue a straight, and the capillaries a winding, zig-zag, and curved course. Some of the vessels seen in the eye run in perfectly straight lines, and as they are greatly magnified they appear to run a considerable distance without receiving or giving off branches. It does not seem to me that this is to be considered as any sufficient mark of distinction between these two sets of vessels, as seen in the eye. In the vessels which pursue a straight course, the lateral pores are seen as distinctly as in the others.

Professor Fohman, of Liege, who has paid great attention to the investigation of the absorbent system, thinks that he has ascertained that the ultimate termination of the lymphatics is not in simple and open radicles, but in anastomotic plexuses, which become finer and more delicate as they approach the surface, whether of the skin or of the mucous or serous membranes. There are not, therefore, open orifices at the extremities of these vessels; and if any orifices exist at all, they must be in their parietes or tunics.

It has been supposed by many physiologists that there is an immediate communication between the minute absorbents and the capillaries. It does not seem to me probable, though I have no direct proof either for or against it. I believe, however, that now the true form of the capillaries has been determined, anatomists generally will feel far less disposed to place any confidence in injections, as proving a direct communication between these two sets of vessels, than they have done hitherto. I can conceive it very easy to force injections through the lateral pores of the capillaries into those of the lymphatics, and vice versâ. Such is the tenuity and fragility of the coats of these vessels, that they are very easily ruptured, especially when they have been dead for some time, and putrefaction has commenced.

I would also suggest, that as absorption frequently continues for a short time after death, many minute vessels, which circulated red blood during life, may be then found to contain only colorless fluids, and may thus be mistaken for lymphatics emptying directly into the veins.

The capillaries are seen in the transparent parts of the eye by day light and by candle light. The greatest number of them is seen when the eye has been exposed to a bright light, or when we have been looking very intently at some object, and have afterwards permitted the pupil to become dilated by exposing the eye to a less brilliant light. By candle light I can see them by partly closing the eyelids and looking at the candle with one eye, so that the light is refracted in such a manner that the candle becomes invisible, though immediately in the sphere of vision, and only an irregular sheet of light is seen, upon which the vessels appear to be distributed. They of course partake of the color of the light by which they are seen. They appear as if floating in the air at some distance from the eye. That distance may be varied by placing some body, as a book, in the sphere of vision, and gradually bringing it nearer the eye; they are then seen either upon, or nearer to the eye than, the body so placed. We may thus bring the image of the vessel

as near as we please. When the vessels appear to be at a distance, they are seen greatly magnified. Thus I frequently see vessels which cannot exceed a few lines in length, or the finest hairs in diameter, as if they were a foot or even more in length, and a quarter of an inch in diameter; in this case, however, they are seen very indistinctly, and I prefer observing them when they are not nearly so much magnified.

To most persons the announcement of the fact, that they can see, in their own eyes, the appearances I have here described, will appear very astonishing, and will no doubt be received with considerable incredulity. But it is nevertheless true. Most adult persons must, at some time of their life, have seen (very indistinctly, it is true), the capillaries of their own eyes. To them they would appear as moats or specks, or as a dark vapor or cloud floating in the air, to which, on account of their indistinct form and fleeting appearance, they would pay little or no attention. They would have no desire to examine them, as they could have no hope of gaining any information if they did. They would as soon think of running after an *ignis fatuus*, when they knew it to be such, as of endeavoring to discover what these objects were; and how many things are left undone, solely because we do not see or believe in their possibility? I myself had seen the capillaries in this indistinct manner, long before the subject was particularly forced upon my attention. I do not believe that at the time I first noticed them, there was anything peculiar in the state of the vessels of my eyes. At present they *may be* somewhat more injected than usual, and the parietes of some of them a little thickened; this, together with the long experience I have had in observing them, may be the cause of my seeing them so very distinctly. Though in the daily practice, for more than five years, of observing the capillaries in this way, I do not perceive that my sight has been at all impaired; it has always been good, and I believe never better than at this moment.

Had it not been for the fortunate accident mentioned at the commencement of this paper, I should probably never have detected the existence of the capillaries in the transparent parts of the eye. The circumstances there mentioned were peculiarly favorable for their discovery; and besides the favorable external circumstances, there is another, deserving of notice; my perceptive faculties were at the time peculiarly active, having been previously called into full play in observing the minute operations of the spider. Hence I am probably indebted to that insect for the discovery of the true form and structure of the capillary vessels, and for the pleasure of seeing one of the most beautiful objects which can possibly meet the eye of the physiologist.

I do not depend for proof of the accuracy of my observation on my own experience alone. Others have seen the capillaries in the same manner as myself. One non-professional gentleman, in particular, remarkable for acuteness of observation, to whom I showed a drawing of one of these vessels, immediately recollected having seen something in his own eyes which he thought bore some resemblance to it; but having paid no particular attention to the subject, he could not speak with confidence. A few hours after, he told me that he saw something in

one of his eyes which exactly corresponded to the vessel I had represented in the drawing, except that it had not the particular curve I had given it. I replied that that was not essential, and that the objects seen might be straight or curved, or in fact assume any form which the capillary vessels possess. Some days after, he told me the more attention he paid to these objects, the more he saw them, and even complained of their being troublesome to him, and expressed a fear lest their appearance should be the premonitory symptom of some disease of the eyes, as cataract, amaurosis, or the like.

I believe that every intelligent person who is possessed of good sight and the necessary concentration of mind, and acuteness of observation, will be able to see them, by making use of the proper means. I have no doubt that in a short time hundreds will be able to certify from their own experience to the truth and accuracy of many of my observations. I do not, however, expect all of them to be very soon confirmed, for that will require long experience, and more time and attention than most persons will be willing to devote to the subject. It will soon cease to appear wonderful that the capillaries in the eye are now seen; the matter of astonishment will be that they were not seen before.

This mode of observing the capillaries is as satisfactory as it is novel. Such is the tenuity of these vessels, so exactly do they correspond in color and probably in texture with the parenchyma of the parts in which they are found, that the very existence of the seriferous capillaries has never been demonstrated, even by the microscope. Many celebrated physiologists, as Mascagni, Prochaska, Richerand, &c. deny that any such vessels exist.

Until now, we have had no anatomical proof of the existence of lateral organic pores in the parietes of the capillaries, and some of the best anatomists and physiologists of the present day, denying the existence of the exhalent vessels of Haller and Bichat, believe that the fluids enter and escape from these vessels, by means of imbibition and exbibition through inorganic pores, i. e. such pores as exist in inorganic matter. When the true structure and functions of these vessels are better known, it will be seen how inefficient such pores would be. I doubt if the existence of the organic pores would ever have been detected in any other situation, or by any other means, than those which I have pointed out. I doubt even now, when their existence has been proved, if we shall ever be able to verify it in any other way. The microscope, in all probability, never will detect them.

As these pores are seen in the living body, and in a part so delicate as the eye, we cannot attribute their existence to the knife of the anatomist or to rupture from mechanical violence; and from the constancy and universality of their existence, we cannot attribute it to disease or accident. Had they been observed only in some of the lower animals, it might possibly have still been denied that they exist in man; this, of course, cannot be done at present. By observing the capillaries in the eyes, we detect them in the very act of performing their functions.

For the sake of precision and uniformity, which are very desirable qualities in anatomical and physiological language, it would be well to

apply the epithet *capillary* exclusively to those vessels whose parietes are pierced with lateral organic pores, and which perform some other function than that of merely conveying the blood. The other blood-vessels, however minute, should be considered and spoken of as arteries or veins. We may also distinguish the capillaries by the epithets sanguiferous and seriferous, or red and white, from the nature and color of the fluids which they convey.

Some observations on the Physiology of the Capillaries.—In entering upon the consideration of the functions of the capillaries, the first inquiry which naturally presents itself to the mind, is, upon what the motion of the blood in these vessels depends? Whether it is caused by the impulse communicated to the circulating fluids by the contraction of the heart and elasticity of the arteries, or by any impelling power which the capillaries themselves possess. When physiologists began to recover from the first dazzling effect of Harvey's brilliant discovery, they saw the necessity of the existence of some other motive powers than that of the heart. What those motive powers are, has long been a matter of dispute among physiologists. M. Magendie and many other modern physiologists contend that the motion of the blood in the capillaries depends entirely upon the impulse of the heart, and elasticity of the arteries and of the capillaries themselves. But this opinion appears to be entirely inconsistent with the known properties and functions of these vessels. It is entirely contrary to, and inconsistent with, many physiological and pathological phenomena. It will not explain local determinations of blood, nor local anæmia. M. Magendie is obliged to acknowledge this, and imputes them to the influence of innervation. I quote his opinions from a work lately published by him, entitled "Leçons sur les Phenomènes Physiques de la Vie."

"Far be it from me, however, to fall into the opposite error of exaggerating the importance of physical explication in interpreting the phenomena of which the animal economy is the seat. Thus why do we see the face become flushed or pale from the influence of moral emotions, more or less lively? Whence those changes of color and of temperature which the skin undergoes from the influence of causes as numerous as varied? This want of harmony between the movements of the heart and the capillary circulation necessarily indicates that there is here something peculiar, something which at least, in the present state of our knowledge, cannot be explained by physical laws. It appears to me probable that it is by the influence of innervation that these modifications are effected. And hence when any part whatever of the living body is completely withdrawn from the influence of the nervous energy, its circulation very soon becomes deranged and even suspended."—P. 202.

It is well known that in asphyxia the circulation of the blood is arrested in the capillaries of the lungs, long before the action of the heart ceases, even when the mechanical phenomena of respiration are perfectly well kept up. M. Magendie's theory of the circulation will not explain why the blood is sooner arrested in the pulmonic capillaries than in the systemic. The former being nearer the heart, should continue longer, according to it, to circulate blood, even allowing for the weaker

power of the right ventricle. It will not explain why the action of some of the secretory organs is almost entirely, if not altogether suspended, while that of some others is at its greatest activity. It appears to me the height of absurdity to suppose that the proportional quantity of blood which flows through a part can be constantly and invariably calculated by the size of its arteries. In the systemic capillaries the blood must circulate after it has been deprived of its nutritious and stimulating properties. As they are also agents of absorption, the absorbed fluids must circulate in them. Now, secretion, exhalation, and absorption, would be constantly interrupted if the motion of the blood in these vessels depended on the impulse of the heart. Suppose, for instance, that mucus was in the process of being formed in one of the capillaries; it might, according to this theory, be forced by the contraction of the heart, through it into the veins. Exhalation and absorption alternate in the capillaries; now by this theory, absorption could not take place. Before a capillary can absorb, it must in a great measure empty itself of the fluid contained in it, by passing it forward into the other capillaries or into the veins, and likewise have the power of preventing the entrance of new blood from the arteries or other capillaries. It must have some attractive power by which it draws the extravasated fluids into its cavity. In one of the capillary vessels I have observed a movement very much resembling the peristaltic motion of the intestines; but I have supposed that it may depend upon the floating of the part to which it is distributed in the aqueous humor.

It is my decided opinion that many of the capillaries are at times entirely empty. I have seen parts of some vessels, without at the same time being able to see other parts which I know, from previous or subsequent observation, to be immediately contiguous, in consequence, as I suppose, of those parts not containing any fluid, contracting so as to obliterate their cavity, and in this state having less refractive power, and therefore being invisible. As I have already mentioned, I sometimes see the lateral pores without being able to perceive the parietes of the vessels in which I know, from previous observation, they are situated, though I can see in every direction around them. Frequently, while watching these apparently isolated pores, I see the vessels to which they belong spring up, upon the sight, as if from the entrance of fluid into them.

M. Magendie denies that the capillaries are possessed of any specific contractile power, and imputes their contraction entirely to elasticity. Now I contend that the blood in these vessels must be moved by some other power than the impulse of the heart, or they must be possessed of some other contractile power than simple elasticity. I have seen in the eye one part of a quite large vessel, so much contracted as to be scarcely visible, while the other parts of the vessel, immediately contiguous, were more than usually distended. Now if the power which moves the blood in the capillaries be the impulse of the heart, and if they be not possessed of any other contractile power than elasticity, I do not understand how one part of the vessel can contract more than another; I think that under such circumstances every part should be contracted

equally. It is not that one part of the vessel is always smaller than the other; as the very part which is seen at one time contracted, is at another time seen very much distended, and vice versâ; different parts of the same vessel are contracted at different times. I have seen this so distinctly and so repeatedly that I *know* I have not been deceived.

If we allow the motion of the fluids in the capillaries to depend on the nervous influence, the existence of any other contractile power than elasticity in those vessels does not seem absolutely necessary to account for their local contractions and expansions. When the fluids are not attracted to a particular part of the capillaries, the elasticity of that part will enable it to contract; when they are so attracted, its elasticity permits it to yield and expand. I think, however, the phenomena observed in the eye are much better explained by supposing the capillaries to possess some specific contractile power.

I believe, then, that the motion of the blood in the capillaries, under ordinary circumstances, does not depend on the heart. There are some animals which have no heart; but yet have a very active capillary circulation. In some animals the circulation continues for a considerable time after the heart has been carefully removed, and then appears to cease only because no new supply of blood can be sent to the arteries. Fœtuses have been born with many of their organs perfect, but without any heart. I believe the motion of the blood in the capillaries to be caused, *under ordinary circumstances*, by the contractility of these vessels, and by a complication of attractions and repulsions, depending, no doubt, on the nervous influence. We know that galvanic electricity exercises a locomotive influence on fluids; and from the great similarity, if not absolute identity, of these principles, it is probable the nervous influence has the same property. This theory will account for local determinations and anæmia, for the alternation of exhalation and absorption, for the suspended and increased action of secretory organs, and for the formation of the secreted fluids in the cavities of the capillaries. It is probable that during sleep the capillary circulation of the organs of the mental faculties is suspended.

For reasons already mentioned, I believe that the capillaries do possess a contractility peculiar to themselves; the phenomena observed in the eye do not, I think, easily admit of any other explanation.

It is in the capillaries considered, in general, as a particular set of vessels, that peculiar and specific changes are effected in the blood. In the systemic capillaries the blood loses its red color, and has abstracted from it the principles suited for nutrition and the various exhalations and secretions. In the pulmonic capillaries it regains its red hue and nutritious and stimulating properties, and is again rendered fit to be sent to the systemic capillaries. These vessels are consequently the agents of nutrition, secretion, exhalation, absorption, sanguification, inflammation, &c. Their functions vary in different parts of the system, and even in different parts of the same organ, according to the various textures of which it is composed. For instance, in the lungs there are capillaries appropriated to the arterialization of the blood, others to the nutrition of these organs, others to the secretion of mucus, others to the exhalation

of the serum lubricating the pleuræ. There is no reason to believe that the form and structure of the capillaries vary in all these different situations; yet their products are all different, and we must impute this to some peculiarity in their vital properties and innervation. A knowledge of their form and size throws no light upon their *vital* functions.

There are the strongest reasons for believing that the various secreted and exhaled fluids are actually formed in the cavities of the capillaries, and that chemical and vital changes are effected in the fluids contained in them in a mass, through the agency of the nervous influence, and that it is not in the very act of escaping from them that the products of secretion are formed. In proof of this I would mention that I have frequently seen the capillaries in the eye assume a dark hue, depending, as I suppose, on some chemical change going on in the fluids contained in them, causing them to become turbid. This appearance is not always limited to the vessels, but is frequently seen in the surrounding parts, as if from the effusion of the turbid fluid.

M. Magendie, in the work I have before quoted, in order to prove that the secretion of intestinal mucus is not an exclusively vital phenomenon, and that it depends in part on physical laws, adduces the following experiment, page 38. "There is one fact to which I wish particularly to invite your attention; it is that the secretion of intestinal mucus is not an exclusively vital phenomenon, but that it depends in part on physical laws. If you wish to have this proved, remove, by carefully scraping with a scalpel, the layer of mucus from any part of the mucous membrane of the stomach, and you will find the next day a new layer of mucus deposited in the same place. Now, since this secretion has taken place in an inanimate tissue, it must necessarily have been effected by physical, and not vital laws." I suppose the mucus to have been already formed in the cavities of the capillaries, during life, and the first layer of mucus having been removed, these vessels to have contracted and forced it through their lateral pores into the excretory ducts of the minute glands, by which it escaped to the external surface of the mucous membrane. I do not believe the mucus in this case to have been formed after death, but during life; and having been once formed, the elasticity of the dead vessels is fully sufficient to convey it to the surface of the mucous membrane.

Secretion is not so slow a process as many suppose. If we turn outwards the interior surface of one of the lips, and carefully remove the moisture from the mucous membrane, we can see distinctly the minute orifices of the excretory ducts of the buccal mucous glands. By waiting the space of a minute, we can see the mucus escaping from these orifices, and in that short time forming a drop nearly equal in size to the whole gland from which it proceeds. Now we can hardly believe this drop to have been formed in that short time solely in the act of escaping through the lateral pores of the capillaries into the excretory ducts of the gland. It is much more reasonable to suppose it was formed in the cavities of the capillaries supplying the gland, and that the lateral pores and excretory ducts are merely channels for its escape. The minute mucous glands are composed of excretory ducts, capillaries distributed to these

ducts, nervous filaments, and mucous tissue connecting these different parts together.

I would propose the term *Secernation* for that process by which the constituent principles of the fluids about to be exhaled or secreted are brought together and combined in the cavity of the capillaries. It is possible that this process may commence in the arteries while yet of a considerable size.

As I have already remarked, exhalation and absorption take place alternately in the capillaries; they are effected by means of the same lateral pores. I have repeatedly seen minute shining particles or globules of fluid entering and escaping from them in the same vessel, thus deciding, by means of *ocular* demonstration, the long agitated question with regard to the absorption of the veins. The capillaries alone absorb, the veins do not, though it has been proved that fluids may enter their cavities by means of imbibition through their parietes. Whenever I have seen a vessel absorbing, it has always been very much contracted; consequently the absorbed fluid could not enter its cavity except by being drawn into it by some attractive power. These vessels have no active power of expansion. In local determinations, as well as absorption, the fluids are drawn into the vessels and distend their parietes.

I do not believe that the existence of open radicles in *some* of the capillaries would be at all inconsistent with their functions. The retrograde motions which those vessels admit of would provide for the passage of their recrementitious fluids into the veins.

The capillaries exercise much less choice with regard to the fluids they absorb, than with regard to those they exhale. They apparently absorb indiscriminately the most deadly poisons, as prussic acid, strychnine, &c. and the most bland and simple fluids. "Twenty years ago no one doubted that the lymphatic system was the exclusive agent of absorption, and now every one knows that any substance, whether acid or alkaline, useful or deleterious, is absorbed as soon as it is placed in contact with our tissues; it is effected, therefore, by imbibition, and all that has been said concerning the intelligence of the pores, is but a fanciful romance entirely out of date at the present day."—*Magendie*, p. 14.

We can now understand why the degree of fullness or vacuity of the veins has such an important influence on capillary absorption. Before the capillaries can absorb, they are obliged to empty themselves in a great measure of their contents, by passing them forward into the veins, which of course they will do with more or less facility, according as these vessels are more or less distended. They must also have the power of preventing the entrance of the fluids contained in the arteries, which are constantly pressing forward to be admitted; hence an excited state of the circulation is unfavorable to capillary absorption. Capillary absorption is of course greatly facilitated by the valves of the veins.

The knowledge gained by observing the capillaries in the transparent parts of the eyes, is capable of many interesting applications. It explains very satisfactorily the physiology of dropsy. In this disease the exhaled fluids probably always exceed the normal quantity; hence the capillaries are kept more than usually active in exhaling, and too little

time, or none at all, is given them for the performance of their other most important function, viz. absorption. It was formerly thought that dropsy arose from the inactivity of the absorbent system; but there is great reason to believe that this system is more than usually active in most dropsies. Does not the anatomist choose a dropsical subject when he wishes to demonstrate the lymphatics, because he knows that they are usually more developed in such subjects as die from chronic dropsy? in consequence, it may be supposed, of having been more than usually active during life. In active dropsy exhalation is too abundant, because too much blood is attracted by the capillaries: in passive dropsy it is too abundant, because they have lost their tone and retentive power; in either case capillary absorption cannot be properly performed. Thus I have known œdema produced by simply keeping up, by friction with the hand, an uninterrupted and increased flow of blood to a part, without carrying it to the extent of producing inflammation. Blisters, which are nothing more than subcuticular dropsies, are no doubt produced on the same principle. I have also seen œdema of the foot and leg produced very suddenly by the injury of a nerve inflicted in forming an issue just below the knee. Digitalis, in all probability, produces its beneficial effects in dropsy, simply by diminishing exhalation, and thus *indirectly* increasing absorption. It is well known that œdema of the lower extremities is usually diminished or entirely disappears at night, when the patient is in bed. This does not arise solely from the facilitated return of the blood through the veins, when the limbs are placed in a horizontal position on a level with the trunk; it in part depends on the fact that in this position less blood is sent to the capillaries of the lower extremities, consequently exhalation is diminished, and the vessels are allowed time to absorb.

It has long been a matter of dispute among physiologists whether imbibition takes place in the living body. Innumerable experiments and observations have now demonstrated that it does; it is, however, greatly controled by absorption, and is otherwise governed by laws with which we are not yet well acquainted. The very existence, however, of the lateral organic pores in the capillaries, is sufficient to prove that exhalation and absorption do not take place by means of imbibition.

Nutrition is the means by which all organized bodies are originally formed, and as long as they retain their vitality, it is constantly carried on in them more or less actively, in order to counteract their perpetual tendency to waste and decompose. This is a very important function of the capillaries. These vessels receive blood, or such constituent parts of it, from the arteries, as are suited to the nutrition of the different tissues to which they belong; certain chemical or vital changes are, no doubt, wrought in the fluids while yet in the cavities of the capillaries, through the agency of the nervous influence; then either the whole or certain parts of them are permitted to escape through the lateral pores in a fluid state, and are imbibed by the living solids; here those parts which agree in composition with the different tissues are incorporated with, and united to, them by a chemical or vital affinity; the other parts, holding in solution or suspension the recrementitious particles of mat-

ter, are reabsorbed by the capillaries and lymphatics, either to be thrown out of the system as excrementitious, or, after having undergone certain changes in the lungs, to be again returned to the systemic capillaries.

Though it has been placed beyond all doubt, by innumerable experiments and observations, that the lymphatics really do absorb, the exact range and purpose of their function is by no means well known. While some physiologists regard them as the exclusive agents of absorption, others believe that, under ordinary circumstances, they take very little part in it. M. Magendie, in the work I have before quoted, expresses his opinion as follows.—"I have convinced myself that most commonly the lymphatic vessels are not filled with fluids, nor traversed by an interior current, and, therefore, on most occasions, cannot be the agents of absorption. The veins, on the contrary, whose function it is constantly to reconvey the blood from the periphery to the centre, ought justly to be regarded as the ordinary avenues by which the extravasated fluids re-enter the circulation. And besides, is not that which anatomy authorizes us to assume, fully confirmed by the results of the numerous experiments which I have made with a view of determining this point? There is only one great absorption, that of the chyle, which forms an exception to this general law; and that is of an entirely distinct kind, and is deserving of our especial attention."—Page 26.

May, 1837.

Mass. Med. Society.—Owing to the length of Dr. Alexander's communication, the account intended of the late anniversary is necessarily postponed to another week. The following, however, comprises the list of Councillors for Suffolk District the ensuing year.

Drs. J. Jackson, B. Shurtleff, J. C. Warren, J. Randall, G. C. Shattuck, W. Channing, J. Bigelow, Geo. Hayward, Enoch Hale, S. D. Townsend, J. Ware, Z. B. Adams, D. Osgood, E. Reynolds, J. Homans, W. Strong, J. Jeffries, G. B. Doane, W. Lewis, G. W. Otis, S. Morrill, J. V. C. Smith.

Dr. Geo. C. Shattuck was re-elected President, and Dr. Nathaniel Miller Vice President, on the following day, by the Council.

Surgical Observations on Tumors.—A beautifully printed octavo, containing six hundred pages, with numerous colored engravings, was published by Crocker & Brewster, yesterday, from the pen of Dr. John C. Warren, who leaves Boston the present week, for Europe. We shall soon be ready to speak more at large on the value of this splendid work.

Plague.—Such is the general prevalence of the plague in very many parts of Asia, and Turkey in Asia, with which American vessels have a constant intercourse, that, under the present culpably slack system of sanitory prevention, there is great danger that that awful scourge of mankind will be imported into this country, either in rags or wool, or both, which are collected in the very plague districts, where hundreds a day are dying. They manage much better in England and France.

Connecticut Med. Society.—At the late annual meeting, Dr. Miner, who has been long honored with the presidency, declined a re-election.

The address delivered by him on the occasion of his resignation, is placed, in part, in the order of publication in the Journal. Silas Fuller, M.D. was elected President; Elijah Middlebrook, M.D., Vice do.; Luther Ticknor, M.D., Treasurer; and Charles Hooker, M.D., Sec'y.

Fever in Antigua.—A fever of a very fatal type has been a considerable time raging at this place, which the physicians seem to have no power of controlling. At the last accounts, the mortality was terrible.

Chinese Eye Infirmary.—From a communication, recently received from Canton, the following gratifying facts have been gathered. The Eye Infirmary has evidently been gaining favor with both natives and foreigners, ever since its establishment. The expenses, since its erection last season, if we recollect rightly, have been not far from $1200, and the contributions by strangers have exceeded that sum by about $300. The entire number of patients, up to Sept. 8th, 1836, was 1,912. So great is the press of business that vast numbers are obliged to go away without being operated upon, owing to the impossibility of having everything done by one single oculist—who is without an assistant.

Whole number of deaths in Boston, for the week ending June 3, 20. Males, 10—Females, 10.

Consumption, 2—smallpox, 2—debility, 1—croup, 1—lung fever, 1—inflammation of the lungs and pleura, 1—by a fall from a house, 1—infantile, 1—inflammation of the larynx, 1—injury of the head, 1—old age, 1—cholera morbus, 1—inflammation of the bowels, 1—bronchitis, 1—puerperal fever, 1—cancer of the stomach, 1—chronic pleurisy, 1—stillborn, 5.

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